IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Volume-5, Issue-6 E-ISSN: 2347-2693

Comparison of Feedback based and Non-Feedback Based Protocols for improvement of TCP in MANETs

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Available online at: www.ijcseonline.org

Received: 06/May/2017, Revised: 15/May/2017, Accepted: 10/Jun/2017, Published: 30/Jun/2017

Abstract— Mobile Ad-Hoc Networks (MANETs) have gained a lot of popularity as a means of providing continuous connectivity of network and Internet to mobile computing devices, independent of their physical location. The routing protocols are needed to support the network in such environments. MANETs are used for enhancing the communications with a rapid score of flexibility. The networks will create an interconnection with other connections using IP as the appropriate connecting protocol. Transmission Control Protocol (TCP) is widely applied in the endwise transport layer communication practice. The system has a scheme of self-generating error checks and controls. Its performance is optimum in the wired-networks where packet losses resulting from congestion are experienced. These packet losses could be specifically attributed to the Bit Error Rate (BER) and disconnections during mobility. The application of the standard TCP on this networks will lead to degradation in performance. This paper compares the Feedback Based and Non-Feedback based approaches typically used for improving the TCP protocol performance in MANETs based on secondary data collection methodology.

Keywords— MANETs, Feedback Based TCP, Non-Feedback Based TCP

I. INTRODUCTION

The fast growth in mobile computing devices has demanded the call for the establishment of the continuous network that is independent of the physical location [1]. A mobile Ad-Hoc network is an interconnection with a selected group of mobile computing devices that that communicate with each other using wireless radios and without any help of physical network infrastructure. TCP/IP is a standard network protocol that is linked to the internet and its association with the mobile ad hoc is paramount. This will aid system allows some of applications and ease of integration with the internet. However, the performance of TCP is low in wireless networks due to packet losses and corruption resulting from the associated wireless errors [5] [10]. This research will concentrate on the TCP performance as a comparison to Ad-Hoc networks. This will involve the study of the challenges impacting the TCP protocol performance and the remedies of the same.

Rest of the paper is structured as follows, Section I contains the introduction of about the background of this paper including various approaches in addressing performance problems of TCP over MANETs., Section II contain the related work of including the background of this study, past work by other authors, Section III containing the research design is focused on how the authors have gone about evaluating the past work, the criterions, etc., Section IV contain the study and comparison of various Feedback and Non-Feedback based protocols that have been offered in the past along with their relative comparison, Section V contain the findings and recommendation of the authors based on this study and Section VI concludes the research work with the way forward.

II. RELATED WORK

A. Overview of MANETs and TCPs

MANETs are proper applications in disaster rescue, battlefield communications, inimical monitoring of the environment without a fixed infrastructure. This situation requires a reliable means of data transfer to the desired destination. The standard TCP has been the primary protocol deployed in performing the transfer in the traditional network environment. The wide application of TCP on the internet has made it the only reliable means of data transfers regarding communications on the internet, and within and across the MANETs [9]. The dependability of TCP performance is achieved through the retransmission of lost data packets through the approach of the feedback delay as well as the average deviation obtained from it. The data will be transmitted again if there is no response to the reception from the receiver within some time interval. The system reliability of the wired networks is designed to assume to experience packet loss through the congestion only. Similarly, MANETs suffer the packet loss due to MAC layer, route breakages, and errors in the wireless channels [10]

B. Challenges facing TCP performance over Mobile Ad-Hoc Networks

The characteristics of MANETs degrade the performance of the TCPs. Some of these characteristics include fading of wireless channel signal strength due to interference, random access collision, hidden terminal issues, and constant route breakages resulting from node mobility. These challenges are catalogued into channel error, mobility, mobile routing, and medium contention and collision [2] [15]. In line with the security aspects of mobile ad-hoc networks, wireless networks are normally predisposed to a number of security challenges, since the interference on the transmission channel is easier compared to that on wired networks. Similarly, it is possible to carry out a Denial-of-Service Attacks (DoS) in the MANETs. This can be done by merely scrambling the frequency bands implemented in the network. In keeping with [12], the DoS attack is regarded as one of the most severe attacks made in mobile ad hoc networks. In the efforts to mitigate such risks and fix the existing network flaws, the most recommended protocols for implementation in order to protect against this kind of attack have counteracted with failure owing to node movement, deficiency of wireless connection, and scalability challenges. Additionally, the attacker can simply launch an attack on one single physical node in the MANET with the purpose of launching a corresponding attack on the entire existing resources of the network. This severe attack commences in a situation where a large capacity of segments is forwarded to a target machine via the concurrent collaboration of a large number of devices that are spread within the network.

- Channel errors

This kind of errors arises from the corruption of packets in transition leading to the loss of either data packets or acknowledgements (ACKs) in the TCP. When the timeout occurs for sender to receive acknowledgement within the RTO, the sender will minimize the congestion window to one packet and retransmit the lost packet. The intermittent errors in the channel may cause the congestion in the window hence reducing its transmission size and resulting in a low throughput [4][6]

- Congestion

TCP is a transport layer protocol that utilizes the network bandwidth fully making the Ad-Hoc networks to undergo congestion. Furthermore, the route changes, the unpredictability of the MCA delay, the variation in the window size, and the rate of data transfer will no longer be accommodated by the Ad-Hoc networks [6]. The computation of the size for the previous window size for the new route may be insufficient for the window size, and this results in network congestion. This causes a buffer overflow and raised the contention level which lowers the TCP performance.

- Multi-path routing

The use of few routes in packet transmission is not reliable due to frequent link breakages. This causes the delay in the route re-computation. This calls for the need to use Temporarily Ordered Routing Algorithm (TORA) protocol to be established between the sender and the receiver and the multi-path routing for packet transmission [11]. This will result in different times of deliveries, and the TCP will interpret this kind of late packets as congestion. Essentially by bearing in mind QoS limitations and simulated ants, the design of an intelligent version of classical Temporally Ordered Routing Algorithm (TORA) has the advantage of increased network period and reduced packet loss. Concurrently, it has an average End-to-End-Delay that renders this algorithm appropriate for real-time and multimedia applications [11]. When network partition takes place, this algorithm is programmed to identify the partition and delete all invalid paths. The alternate algorithms have not paid attention to resolving this matter. TORA also takes into account the node drain rate as a critically essential QoS limitation for evading congestion in the network [13]. Furthermore, this algorithm chooses only those nodes for routing that fulfil the energy limitation. The ACKs will thus produce multiple copies of ACKs that provokes the congestion control algorithms [4][7]

- Mobility

Mobility includes the breakage of linkage between two nearby nodes when one mobile node is beyond range of the second node [15]. These link breakages cause the packet losses. TCP cannot differentiate between the losses owing to failure from the ones from congestion. The discovery of the new route may take longer time than the normal RTO. This delay will invoke the TCP sender to activate the congestion control timeout [10]. Multi hop connectivity schemes can be exploited so as to lengthen the mobility and increase the coverage region, but then again it boosts the delay time in the same time. Generally, literary evidence indicates that the more relay nodes (hop), the longer the delay time [1]. At the same time, energy consumed is also influenced as direct transmission is considered to have more combined energy needed compared to indirect communication approach. Hence, the modification of relay nodes will impact on the sense of balance of delay time and energy dissipation within the network.

- Contention and Collision of Medium

The common Media Access Control (MAC) measures such as the code IEEE 802.11 are associated with the multi-hop and Ad-Hoc networks. In this regard, the close nodes contend for wireless shared before transmission. Three problems borne to this transmission are unfairness, hidden terminal issues, and exposed terminal problem. The hidden node is contained in the interfering proximity of the receiver but it is out of range for the transmitter. This hidden node may collide with the packet data. The exposed node is well within the transmitter's sensing range but is beyond the range for the interfering receiver. The unfairness is created by favours from the Binary Exponential Back-Off scheme [5]

- Energy efficiency

The mobile nodes must be having adequate energy for a successful node. The network life is prolonged through battery recharge or provision of efficient energy. Supplementary relay nodes having suitable metrics like energy and determination of routing between source and final destination are required for the network devices. This considerably minimizes the energy usage required to deliver packets in Wireless Ad-Hoc Network whereas maintaining the connectivity of dynamic nodes [14]. Therefore, energy is an important parameter in the events of retransmission and high session throughput.

C. Ways of Improving Performance of TCP in MANETs

The several systems that have been suggested to increase the TCP performance compared to the Ad-Hoc networks are classified as TCP with feedback and TCP without feedback. The deployment of TCP with feedback to non-congestion helps in differentiating between the actual congestion in the network and other issues such as channel errors, route failures, and link contention [1][3]. TCP without feedback allows the TCP to adapt the variation in routes without the depending on the feedback from the network. The idea is to keep away the suspected complexity and cost in Ad-Hoc networks brought about by feedback mechanism [3].

1) TCP with Feedback

In Feedback-based TCP optimisation approach, we are considering TCP-Feedback, TCP ELFN and ATCP which are commonly used.

- TCP-F

The topology in the mobile Ad-Hoc networks may change very quickly owing to the mobility of the mobile hosts. The sudden change causes delay and loss of packet data. TCP misinterprets the losses as congestion and invokes retransmission lowering the throughput. This challenge has been solved using the TCP-Feedback to ensure that the sender differentiate between the route failures and congestion in the networks. The sender is then forced to cease transmission without diminishing the size of the window during route failure [8]. In a similar study, the author applied certain methods so as to get good performance in TCP connections with feedback system [13]. This used a feedback scheme that was proposed and is known as the Feedback based TCP (TCP-F). It was essentially used to ensure that the origin of packets easily identifies incidences of Route Failure Notification packet ((RFN). The process enables it to stop its timers and pause packet transmission. Upon re-establishing the route followed, the origin of packets is updated using a Route Re-establishment Notification (RRN) packet, that sends the signal where it takes up tasks again by releasing timers and picking on packet transmissions again.

- TCP-ELFN

Explicit-Link-Failure-Notification (ELPN) is a feedback technique that informs the TCP source of any link and route failures to not respond to the failures in case of congestion. This method is uses the Dynamic Source Routing protocol (DSR Protocol). The generated ELFN message is implemented by modifying the DSR route failure message to carry ICMP protocol. When the sender node in TCP receives the ELFN, it disables the congestion control mechanisms and goes to a standby mode. A small number of probe packets are still sent out over the network in the standby mode to determine some establishment. If new route is detected, the TCP exit the standby mode and continue as normal by restoring its RTO [8].

- ATCP

Ad-Hoc TCP uses a layer of network feedback to insert a thin light-weight layer known as ATCP in between the IP layer and TCP layer to maintain stability during issues of route failures or high error bit rate. TCP sender is put in a state of congestion control, retransmit or persist respectively depending on the packets losses caused by congestion, higher bit-error rate or route breakage. The scheme will also handle the packet corruption from channel errors [9] [10]

2) TCP without Feedback

In Non-Feedback based TCP optimisation approach, we are considering techniques like TCP-DOOR, Fixed RTO and making the congestion window adaptive to environment on invoking the congestion control mechanism.

- TCP-DOOR

TCP detection of out order and response protocol attempts to improve the TCP performance via detecting and subsequently responding to the out of order delivery (OOO), and, thus avoiding the activation of congestion control mechanism unnecessarily. OOO happens when the packet that was previously sent arrives at a later time than the subsequent packet. The detection of the OOO by the sender of TCP will prompt it to either temporarily disable the congestion control or recover the packets instantly avoid during the congestion avoidance [5]

- Fixed RTO

The normal TCP mechanism to control the congestion involves the TCP doubling the RTO and transmits the unacknowledged packet after the retransmission time expires. In fixed RTO, the required feedback from the underlying layers isn't there. Rather, a simple criterion is adopted to differentiate between the route failures and congestion. When the sender of TCP receives the ACK before the expiry of the second RTO, then it assumes the problem to be the failure of the route instead of network congestion. In this scenario, the unacknowledged packets are retransmitted without having a double status of RTO [10]

- Adaptive congestion and setting of window limits

This strategy is based on the TCP's algorithm of congestion control on exceeds that causes network overload, and high level of strife at the MAC layer. The scheme controls the window capacity by regulating the number of packets through it. The window limit setting strategy dynamically is adjusted according to the current Round-Trip-Hop-Count (RTHC) of the route that can be obtained from the routing protocols like ADODV, DSR, etc. [10]

III. METHODOLOGY

The key objective of this research is to compare the Feedback based and Non-Feedback based approaches that are adopted to improve the TCP performance over the Ad-Hoc networks. Resting on the secondary data, this paper is comparing various approaches to tackle these performance issues. It also discusses the merits and limitations of these approaches without statistically attempting to prove the superiority of one over other. The outcome is desirable to contribute in empirical approach towards selecting either of Feedback or Non-Feedback based method for a given scenario instead of either evaluating all or random way of selecting algorithm for tuning the TCP performance. Here we compare different methodologies that were adopted by researchers in the past duly considering the criterion discussed above using secondary research.

IV. RESULTS AND DISCUSSION

In this approach, the methodology compares the Feedback based and Non-Feedback based techniques to improve the performance of TCP over the Ad-Hoc networks. TCP-Feedback enables the Congestion control algorithm of TCP to be more efficient in a situation where the sender is not in snooze state. Hence, it renders it considerably more sensitive to network jamming that offers a simple solution to minimize the problems that are taking place caused by regular path breaks MANETs. Mobile Ad-Hoc networks (MANETs) have been used in various applications regarding the mobile computations networks. TCP has been the main approach of transmitting packet data across the network. However, the existing variants of TCP network protocols have some limitations. As cited, it takes a complete RTT to initiate detection of each packet loss and it takes a correspondingly extended time in most implementations in order for it to regain lost packet. Concurrently, the network types send increasing acknowledgments that offer little information and subsequently observes a "go back N" or a retransmission method. Hence, each time a packet is lost, it awaits a RTO time that constitutes a significant cost in high bandwidth delay product networks [12].

We summarize the findings from the Feedback and Non-Feedback based techniques based on parameters discussed in earlier section as per below:

Table 1. Summary of findings for Feedback-Based TCP Protocols

Parameters	**TCP-F**	**TCP-ELFN**	**ATCP**
Channel errors	High throughput causing corruption of packets during transmission	Less corruption, and invokes a standby mode	Has route failure
Congestion	Misinterprets packet losses as congestion	Identifies the existing congestion	Reduces congestion by raising stability
Multi-path routing	Causes delays in route re-computation	Has less delays as they are minimized	No delays because of high bit rate
Mobility	Breakage of linkage between two nearby nodes	Initiates notification for incidences	Maintained stability during issues of route failures
Contention and Collision of Medium	Leads to unfairness, hidden terminal problem, and exposure to terminal problem	Identifies and sends notification on existing collisions	Disables the congestion control mechanisms
Energy efficiency	Needs adequate energy	Has more energy requirements	Has most energy requirements

Table 2. Summary of findings for Non-Feedback Based TCP Protocols

Challenges	**Adaptive congestion and setting of window limits**	**TCP-DOOR**	**Fixed RTO**
Channel errors	Network overload	More network overload	Most evident network overload
Congestion	No activation of congestion control	Reduced activation of congestion control	
Multi-path routing	Dynamic strategy setting	More dynamic strategy setting	Most dynamic strategy setting
Mobility	Dynamic adjustment strategy	Delays of packets' delivery	Transmission time reduced
Contention and Collision of Medium	Applies TCP algorithm in network relay	Improves TCP performance	Transmits unidentified packets
Energy efficiency	Low energy efficiency	Medium energy efficiency	High energy efficiency

The above tables indicate that both Feedback based and Non-Feedback based protocols have their own unique advantages and disadvantages which can be recapped as per below:

A. Feedback Based Protocols

Feedback Based Protocols provide more stable network owing to their ability of detecting route failures and subsequent retransmission. On the contrary, these protocols are prone to the in-flight corruption of data including CRC errors, misinterpretation of packets, etc.

B. Non-Feedback Based Protocols

Non-Feedback Based Protocols are more effective in ensuring the accuracy of packets transmitted, thereby reducing the rate of retransmission. They can detect and notify in case of any losses and corruption as well. However, this very advantage negates itself in certain scenarios wherein they end up retransmitting unwarranted, unidentified packets in addition to having high energy requirements.

V. CONCLUSION and Future Scope

From the discussion, a deduction can be made on TCP with feedbacks in MANETs and those without. The study has revolved around these two reliable methods that are used for improving the TCP performance in MANETs by mitigating these challenges. TCP are faced with various challenges that includes congestion, channel errors, multipath routing, energy efficiency, mobility, and medium contention and collision. The impacts of failures of routes in feedback and non-feedback based protocols used for the improvement of TCP in MANETs is studied. In a nutshell, the impacts of failures of routes in feedback and non-feedback based protocols for improvement of TCP in MANETs compare in terms of transmission and stability. The TCP with feedback detects route failures and transmit and have a maintained stability. Their limitations are corruption and misinterpretation of packets. The TCP without feedback regulates amount of packets transmitted and has detection and notification features. It is limited by high energy demands and transmission of unidentified packets. TCP Feedback enables the Congestion control algorithm of TCP to be more efficient in a situation where the sender is not in the snooze state. Hence, it renders it much more sensitive to network jamming that offers a simple solution to minimize the problems that are taking place caused by regular path breaks in MANETs. The methodology of this study will increase the throughput, Good-put and reduce the Round trip delay time. Since the overall delay will be minimized, so TCP with Feedback is predicted to perform better than the basic TCP without Feedback. The present scope of the research is limited to empirical data based study, as a scope for future work field trials will make it will be more conclusive and also bring out limitations that may not have appeared in this theoretical work as MANETs have evolved significantly and are being adopted in various means and purposes such as Vehicular-ANET, IoT, etc.

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